

EARTHQUAKE-INDUCED GROUND FAILURE HAZARDS

Liquefaction—as a geologic term, refers to the loss of strength of saturated soils during shaking. An earthquake can cause soil particles to shift and become buoyant, as pore spaces filled with water, which weakens the ability of a soil to support structures on the surface. Liquefaction caused some of the damage to buildings in San Francisco's Marina District during the 1989 Loma Prieta earthquake (photo by U.S. Geological Survey).



Surface rupture—occurs when movement on a fault deep within the earth breaks through to the surface. Fault rupture almost always follows pre-existing faults, which are zones of weakness. Rupture may occur suddenly during an earthquake or slowly in the form of fault creep. Sudden ruptures are more damaging to structures because they are accompanied by shaking. There was over 20 feet of surface rupture near Olema, Marin County, during the "Great San Francisco Earthquake" of 1906 (photo by G.K. Gilbert).



Landslides—are the downhill movement of ground caused primarily by gravity acting on weakened rock or soil. Slopes are weakened by weathering, erosion, saturation, and the addition of weight in the form of artificial fill, structures, snow, or rock. Landslides that occur during earthquakes typically originate from these steep and weakened slopes. A large number of landslides occurred in the Santa Cruz Mountains and along coastal bluffs during the 1989 Loma Prieta earthquake (photo by U.S. Geological Survey).

Seismic Hazards Resources and Earthquake Education Information:

Regulatory Seismic Zonation Maps - www.consrv.ca.gov/cgs/geologic_hazards/regulatory_hazard_zones/index.htm
Earthquake Education Information - www.consrv.ca.gov/cgs/information/EdResCenter.htm

Offices of the California Geological Survey:

Publications and Information Office
801 K Street, MS 14-34
Sacramento, CA 95814-3532
(916) 445-5716

Bay Area Regional Office
345 Middlefield Road, MS 520
Menlo Park, CA 94025
(650) 688-6327

Southern California Regional Office
888 South Figueroa Street, Suite 475
Los Angeles, CA 90017
(213) 239-0878

www.conservation.ca.gov/cgs

THE RESOURCES AGENCY
MIKE CHRISMAN
SECRETARY FOR RESOURCES

STATE OF CALIFORNIA
ARNOLD SCHWARZENEGGER
GOVERNOR

DEPARTMENT OF CONSERVATION
BRIDGETT LUTHER
DIRECTOR



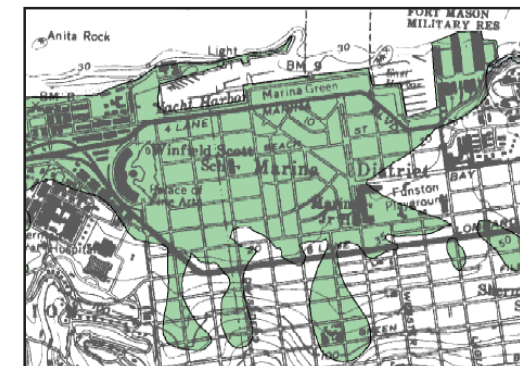
CALIFORNIA GEOLOGICAL SURVEY

REGULATORY EARTHQUAKE HAZARD ZONES

SAN FRANCISCO BAY AREA

NOTE
53

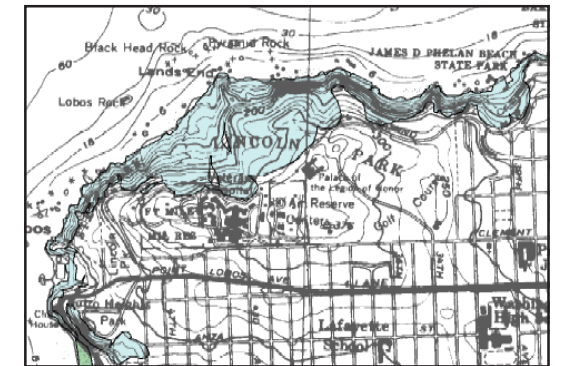
California Geological Survey (CGS) designates zones that delineate areas where ground failure is more likely to increase earthquake damage by liquefaction, landslides, or surface fault rupture (the hazard of strong earthquake shaking is addressed separately by the California Building Code). These areas are commonly referred to as "zones of required investigation." Cities and counties are required by state law to withhold building permits within these zones until geotechnical investigations are conducted to assess seismic hazards on a site-specific basis. If liquefaction or earthquake-induced landslide hazard is identified, appropriate design and/or ground improvement measures must be applied in order to reduce potential for structural failure. More restrictive measures are applied within earthquake fault zones, where proposed structures must be set back from the trace of active faults. In all cases, real property sellers are required to check seismic zonation maps produced by CGS to determine whether property being sold falls within a seismic hazard zone. The seller is required to provide a "Natural Hazard Disclosure Statement" to the buyer.



Detail map of the seismic hazard zones for potential liquefaction in the Marina District of San Francisco.

CGS geologists delineate liquefaction zones by assessing the engineering behavior of soils based on surface geology and geomorphology, measuring soil properties from subsurface borings, assessing the potential degree of soil saturation, and evaluating the potential for such soils to liquefy under estimated levels of ground shaking from future earthquakes. Earthquake-induced landslide zones are based on a similar analysis that also includes mapping locations of existing landslides, and an analysis of rock strength, geologic structure and surface topography in order to assess the stability of slopes under future earthquake shaking. As of April 2006, CGS has released 112 official maps covering about 7000 square miles.

These maps show zones of liquefaction and earthquake-induced landslides. Twenty-two of the completed maps cover parts of San Francisco, Santa Clara, San Mateo, and Alameda counties; these maps are compiled into one map inside this CGS Note. CGS will continue producing seismic zonation maps for liquefaction and earthquake-induced landslides in the Bay region.



Detail map of the seismic hazard zones for potential landslides in the Lincoln Park area of San Francisco.

Earthquake fault zones designated by CGS are delineated on a separate series of maps. CGS geologists place earthquake fault zones along traces of faults where mapping demonstrates surface fault rupture has occurred within the past 11,000 years (Holocene time). Construction within these zones cannot be permitted until a geologic investigation has been conducted to prove that a building planned for human occupancy will not be constructed across an active fault. These types of site evaluations address the precise location and recency of rupture along traces of the faults and typically are based on observations made in trenches excavated across fault traces. As of April 2006, CGS has released 547 official maps statewide.

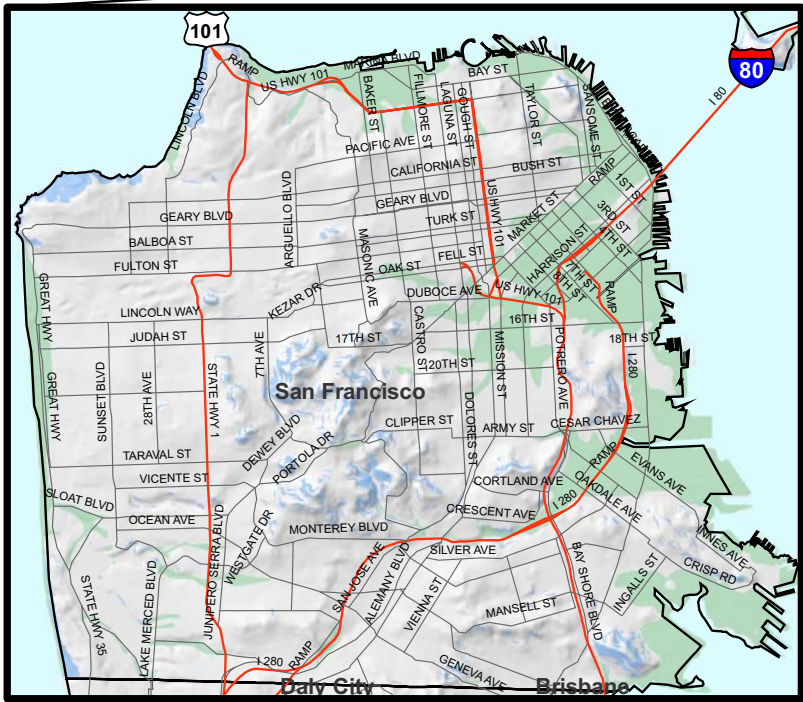


Detail map of the earthquake fault zone for a portion of the Hayward fault in the City of Fremont, Alameda County.

©California Department of Conservation, 2006. Reproduction of this CGS Note for classroom or public education purposes is encouraged and does not require written permission. However, please cite California Geological Survey as source. The Department of Conservation makes no warranties as to the suitability of this product for any particular purpose.

Seismic Hazard Zonation of Northern California




April 2006

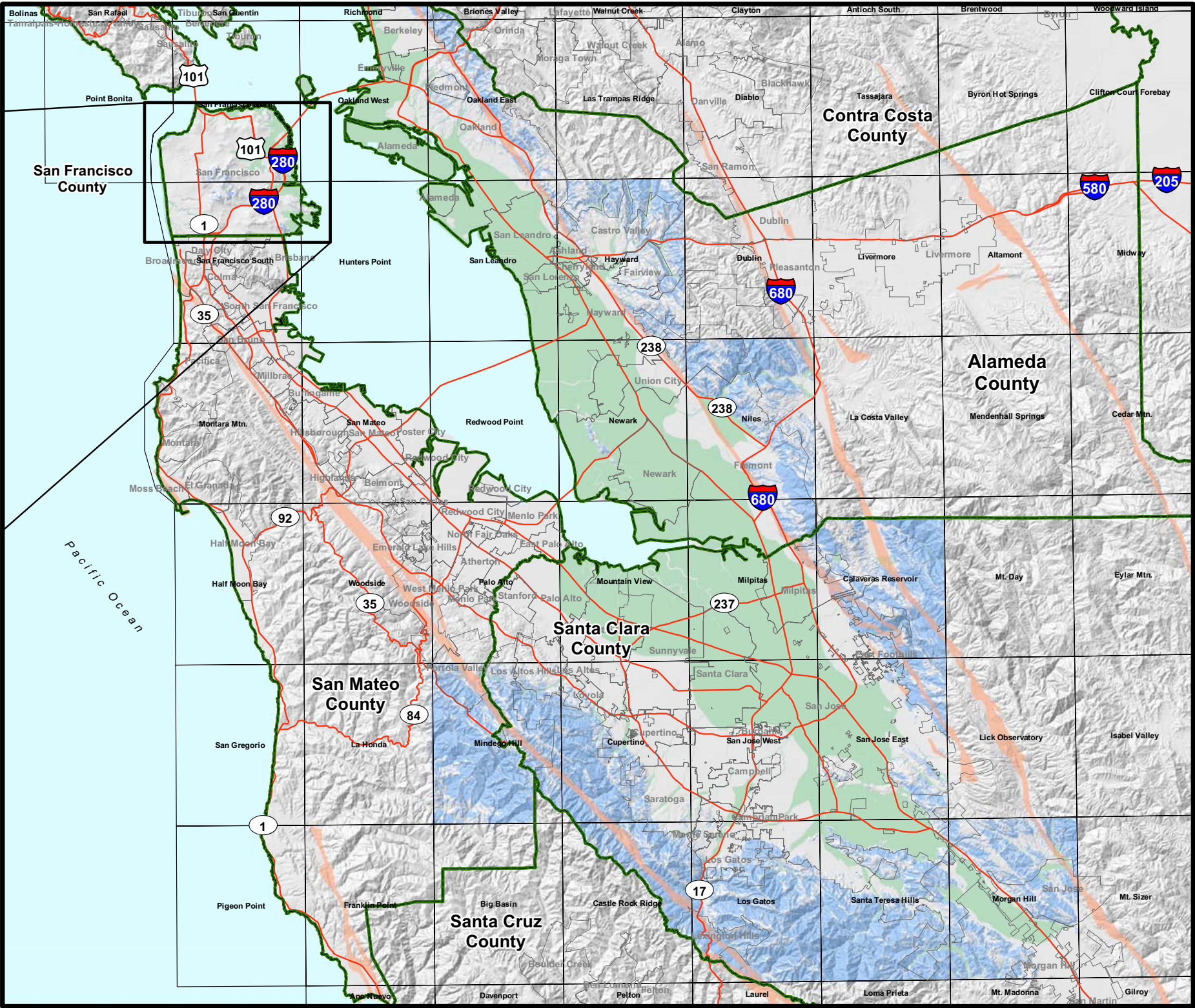


San Francisco

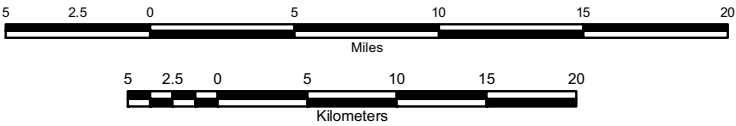
MAP EXPLANATION

Zones of Required Investigation

-  **Liquefaction**
Areas where historic occurrence of liquefaction, or local geological, geotechnical and groundwater conditions indicate a potential for permanent ground displacements such that mitigation as defined in Public Resources Code Section 2693(c) would be required.
-  **Earthquake-Induced Landslides**
Areas where previous occurrence of landslide movement, or local topographic, geological, geotechnical and sub-surface water conditions indicate a potential for permanent ground displacements such that mitigation as defined in Public Resources Code Section 2693(c) would be required.
-  **Surface Fault Rupture**
Regulatory zones encompassing active faults so as to define those areas within which fault-rupture hazard investigations are required prior to building structures for human occupancy.



Scale



DEPARTMENT OF CONSERVATION
CALIFORNIA GEOLOGICAL SURVEY
SEISMIC HAZARDS ZONATION
801 K STREET, MS 12-31
SACRAMENTO, CA 95814
916 324-7299
<http://conservation.ca.gov/cgs/shmp>

